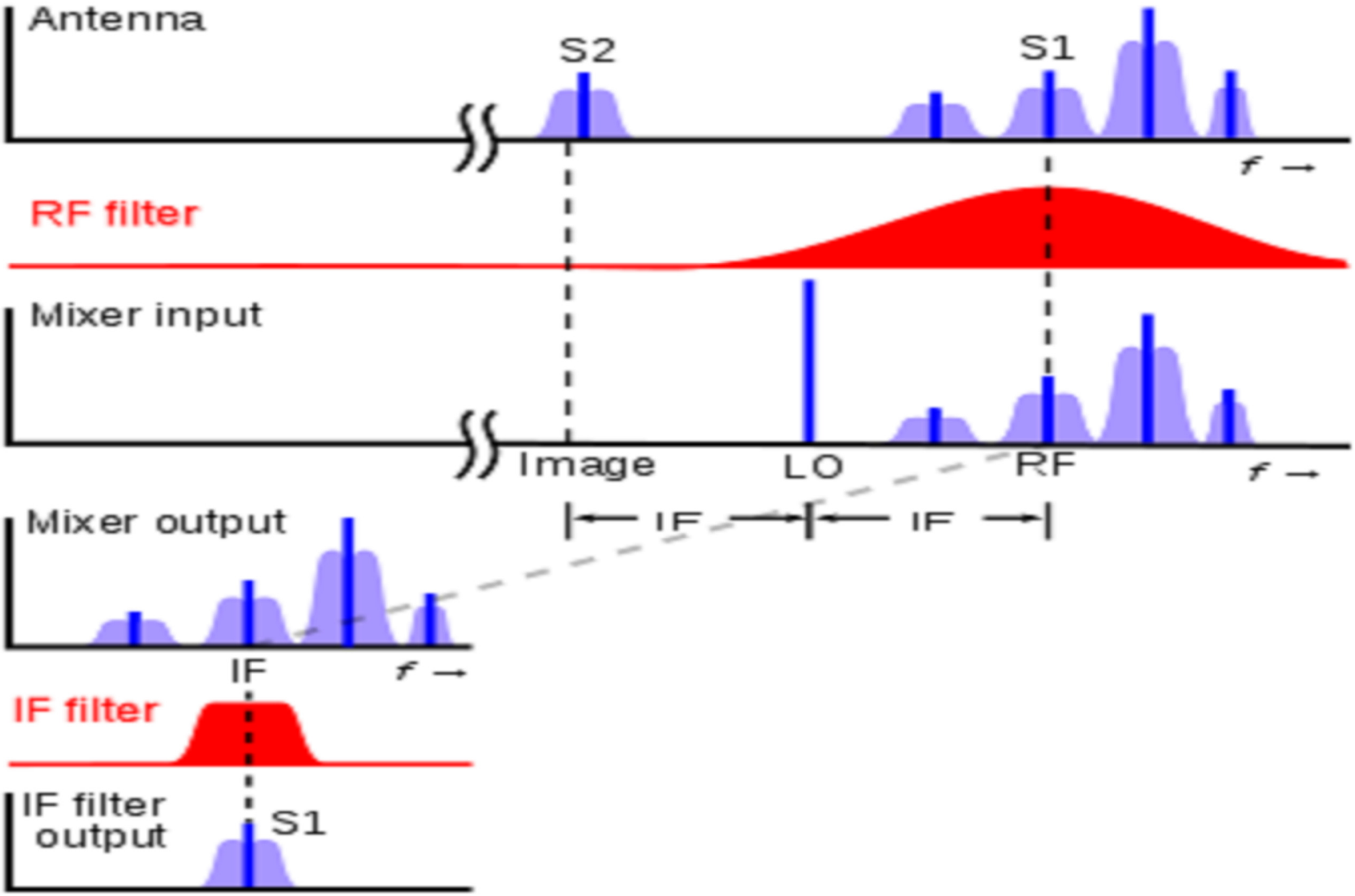
SuperHeterodyne Receivers

Review of part 1
History: Fessenden, Heterodyne principle, 1902
First applied by Armstrong, Superheterodyne, 1918

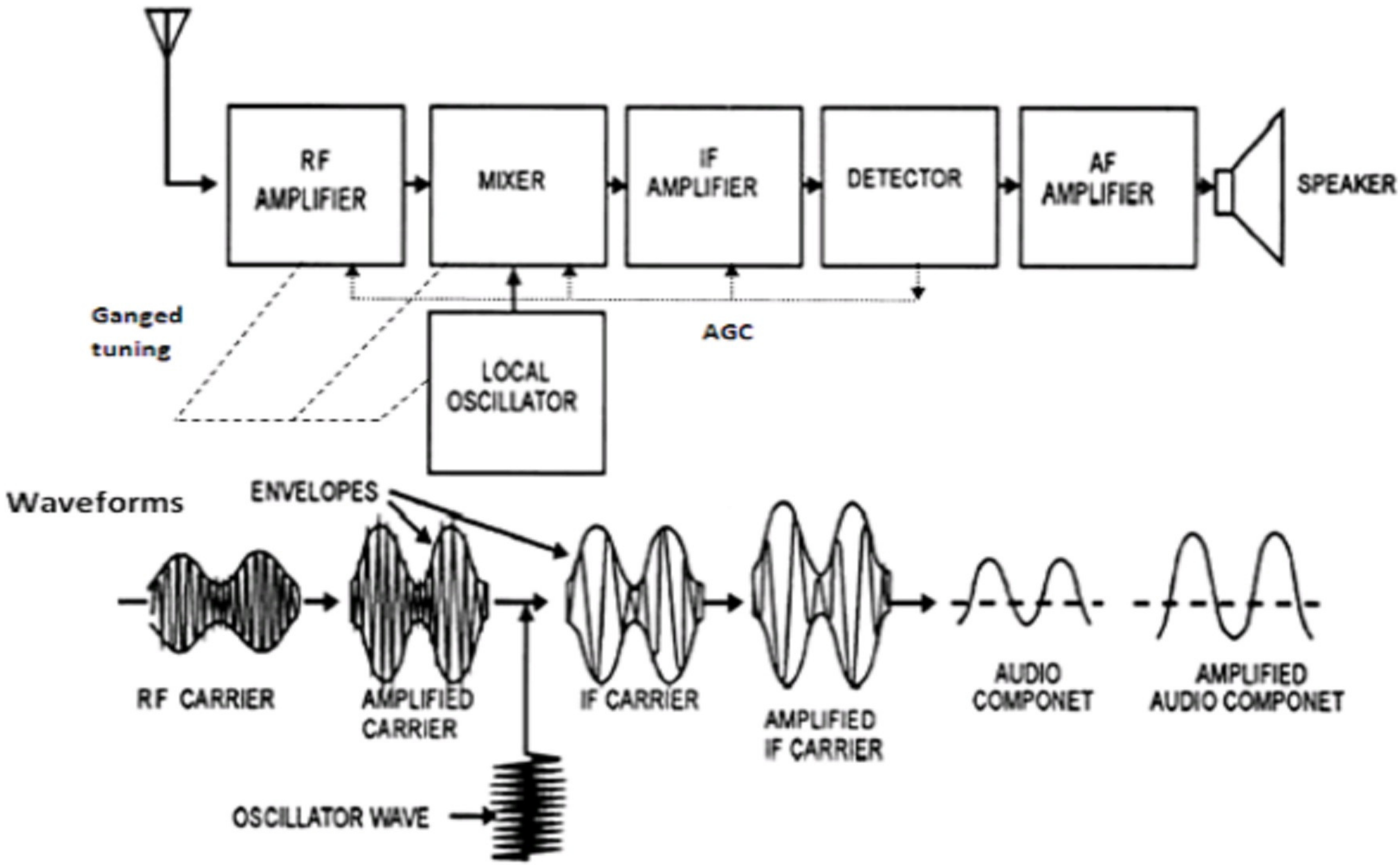
See the wikipedia entry for superheterodyne

Mixer: heterodyning, beating, adding/subtracting of two signals
Receiver: simple block diagrams, signal levels, signal frequencies, IF (intermediate frequency)

Superheterodyne mixing



Typical SuperHet Receiver Block Diagram with signals



Part 2 More about Receivers: Receiver Parameters

- Sensitivity: How weak a signal can be ‘heard’ (i.e. real information extracted)
- Selectivity: Ability to separate the signal you want to hear (this is bandwidth)
- Dynamic Range: Range of signal levels that the receiver can handle without distortion. Our modern receivers have a DR of 100 dB or more
- Linearity: Faithful reproduction of the signal i.e. the output matches the input

- Stability: No drift or change in frequency of the received signal. (oscillator quality on the RX end) (the transmitted signal may also drift)
- Amplification: The receiver must handle signals from less than 1 microvolt to as much as a volt from a nearby station or high power station. This requires the recevier to have variable gain (amplification) to protect the operators ears!   This means the receiver must handle signals that vary in amplitude by as much as 100 dB or a Ten Billion times different!
- There is a lower limit to any possible signal which due to the thermal resistive noise inherent in the receiver which is -174 dBm

See Spreadsheet on Receiver Gain

- I made up this spreadsheet to illustrate both the levels of sound for normal hearing and relate it to the levels of radio signals encountered in our receivers. There are two examples here of how Decibels are used as shorthand for the large difference factors encountered in both hearing and radio and that they can be referenced by the same scale, in this case dBm which are decibels referenced to 1 milliwatt, widely used in amateur radio circles. Also note the S-meter scale which is another example of using decibels with a different zero level selected. The S-meter steps are by 6 db so they don’t fit exactly in the table with the other cells in 10 dB steps but I put them as close as practical so it should be clear with the levels.

So how do we handle this tremendous range of input signals to be able to hear them as audio output signals that are at a reasonable hearing level and not too weak or too strong?

We use a method of sampling the signal level and sending info to earlier stages in the receiver to vary the level of amplification: AGC

AGC: Automatic Gain Control

- The gain of the amplifier stages can be varied (reduced or increased) as necessary to give a fairly constant audio output level.
- Originally we had AVC, Automatic Volume Control, which only adjusted the Audio Amplifier Stage
- AGC was developed later when the technology advanced. We can’t do without it today.

Triple Conversion Receiver Gain Diagram

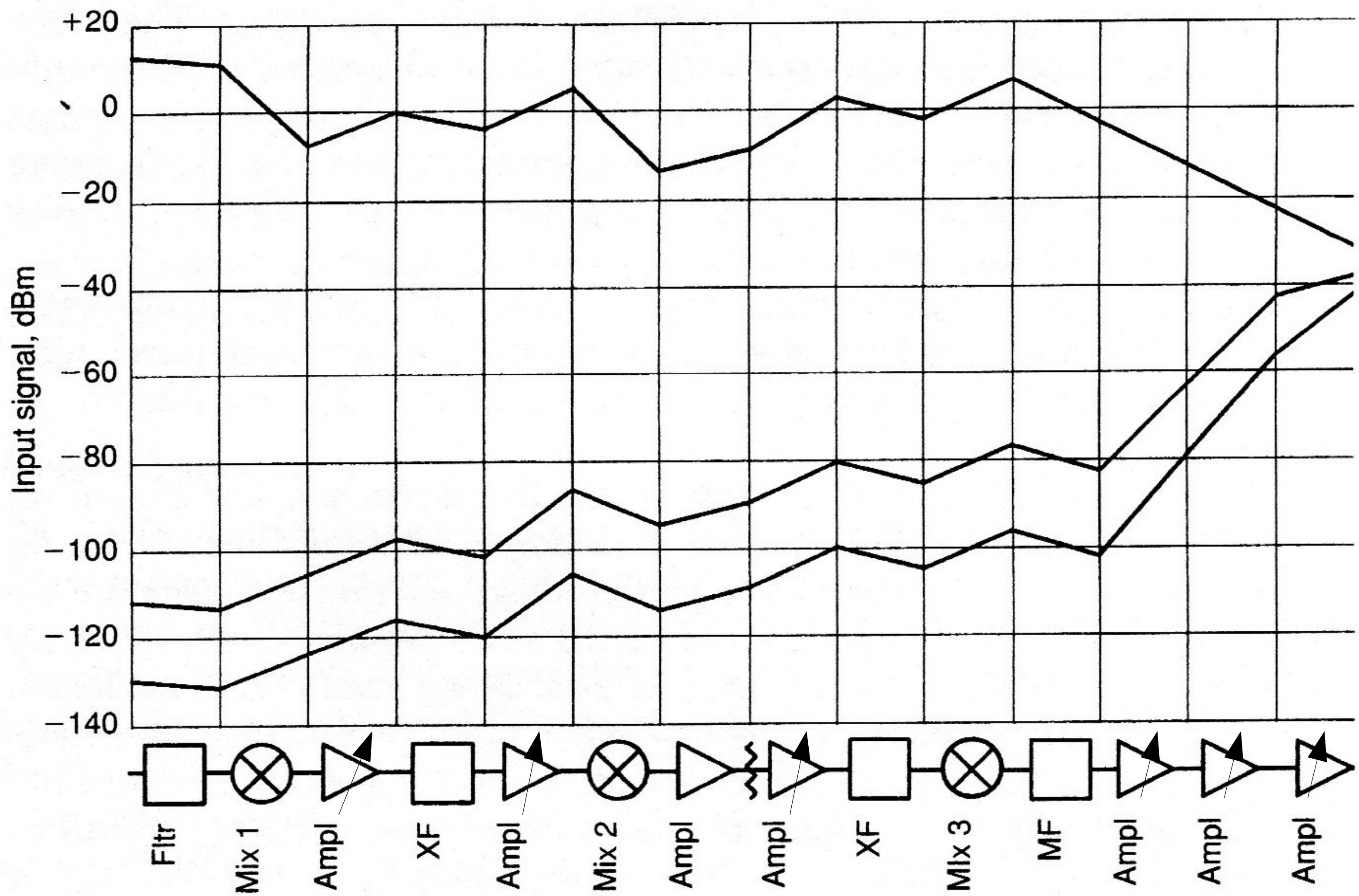


Figure 4.28 The power level for three conditions of signal input is plotted for each stage to plan the gain and AGC distribution.

AGC

- Measure the signal before AF
- If large, send feedback to prior stages to reduce the stage gain
- AVC was similar but we usually got a “Blast” of loud audio from the receivers of the day

Examples

- A -130 dBm ‘weak’ signal needs 90 dB of gain to get to the -40 dBm comfortable hearing level
- 90 dB is a factor of 10 or a gain of one billion times!
- Direct Conversion receiver like a ‘SoftRock’ which converts RF direct to AF (baseband) has a gain of 90 to 100 dB in the Audio Stage and can be unstable and tempramental with that much gain in a single stage (generally limit to about 50)